

NEEGINAN INSTITUTE

WINNIPEG, MANITOBA

WELDING PROCEDURE SPECIFICATION

FOR GMAW

OF CARBON STEEL

Welding Procedure Specification No.: GMA-CS

Date:

February 2010

CWB APPROVAL	ENGINEER'S SEAL
	<i>SAMPLE</i>

1.0 SCOPE

This Welding Procedure Specification covers welding and related operations in accordance with CSA Standards W47.1 & W59, and AWS D1.1 & D1.3, latest editions.

A change in any of the essential variables specified in CSA W47.1-09, which are contained in succeeding paragraphs or detailed on an applicable Welding Procedure Data Sheet (WPDS) will require a new Welding Procedure Specification and/or a new WPDS.

2.0 WELDING PROCEDURE

The welding shall be done Semi-Automatically using a gas metal arc welding process (GMAW).

The joints shall be made in accordance with procedural stipulations indicated in CSA Standard W59 and may consist of single or multiple passes.

Welding shall be in accordance with the CWB approved Welding Procedure Data Sheets contained in Appendix D.

Each Welding Procedure Data Sheet designates the filler wire type to be used for the joint, applicable Codes or Standards, material specifications, the number of the applicable Welding Procedure Specification and detailed information for use in the actual welding of each joint.

3.0 BASE METAL

The base metal shall conform to the specifications for carbon steels as listed in Groups 1, 2 & 3, Tables 11-1 & 12-1, CSA W59-03.

Other materials may be welded, providing the applicable Welding Procedure Data Sheets are accepted by the Canadian Welding Bureau.

4.0 BASE METAL THICKNESS

Base metal thickness from 1/8 inch (3mm) to UNLIMITED THICKNESS may be welded under this specification.

Base metals less than 1/8 inch (3 mm) thick may be welded in accordance with AWS D1.3 providing the applicable WPDS is accepted by the Canadian Welding Bureau.

4.0 BASE METAL THICKNESS (Cont'd)

Where base metals less than 1/8 inch thick are to be welded to base metals equal to or greater than 1/8 inch thick, both CSA W59 & AWS D1.3 apply. In the case of a conflict between CSA W59 & AWS D1.3, the requirements of CSA W59 govern.

5.0 FILLER METAL

Filler metal shall conform to specifications for Solid Mild Steel Filler Metals for Gas Shielded Arc Welding in CSA Standard W48 Latest edition and shall be certified in one of the classifications of that Standard by the Canadian Welding Bureau.

Low-alloy steel filler metal and shielding gas combinations shall conform to the requirements of AWS Standard A5.28.

All filler metals and shielding gas combinations shall be certified in one of the classifications of the above Standards by the Canadian Welding Bureau.

Any decrease in filler wire diameter requires a separate WPDS.

Wire shall be stored in accordance with Appendix A "CARE OF FILLER WIRE".

6.0 SHIELDING GAS

Shielding gas used under this specification shall be a welding grade quality having a dew point of -40°F (-40°C) or lower. The shielding gas/filler metal combination shall be certified by the Canadian Welding Bureau.

Separate WPDS's are required for a change in shielding gas (except as permitted by CSA W48-06 or AWS A5.28, for the given electrode designation) as follows:

- From a single gas to any other gas; or
- To a mixture of gases; or
- In the specified nominal percentage composition of a gas mixture.

7.0 POSITION

Welding may be done in all positions (i.e. flat, horizontal, vertical or overhead), provided the appropriate CWB approved Welding Procedure Data Sheet is available for the relevant position.

Unless called for otherwise on a specific CWB approved WPDS, vertical welds shall be made with the progression of each pass in an upward direction with the exception that:

- a) When using CWB certified filler wire specifically designed for vertical down progress of welding.
- b) For cover or wash passes.
- c) For root passes which are to be removed by back gouging.
- d) When repairing undercuts, provided that the greater of the minimum permissible preheat temperature or 500° F (10 C) is maintained.
- d) If welds are to be made in a vertical down sequence, the welder and procedure shall be qualified on a separate basis.

8.0 PREPARATION OF BASE METAL

Edge preparation of the base metal will generally be done by plasma or arc machine gouging, grinding or by shearing.

Where hand cutting is involved, the edge will be ground to a smooth surface.

All surfaces and edges shall be free from ribs, cracks, or any other defects which would adversely affect the quality of the weld.

Re-entrant corners, except for the corners of weld access cope holes adjacent to a flange, shall be contoured to a radius not less than ½" (12mm).

Transitions shall be ground to provide a suitable joint for a sound weld.

Radii of beam access copes and weld access holes shall provide a smooth transition, free of notches or cutting past the points of tangency between the adjacent surfaces. Surface roughness shall be in accordance with the requirements of CSA W59-03 Clause 5.3.3.

Weld access hole dimensions shall conform to the requirements of CSA W59-03 Clause 5.3.8.

8.0 PREPARATION OF BASE METAL (Cont'd)

All loose or thick scale, rust, moisture, grease, paint, or other foreign material that would prevent proper welding or produce objectionable fumes, shall be removed within 2" (50 mm) of any surface to be welded.

Plate edges & weld preparations shall be visually examined prior to fabrication to detect the possible presence of planar edge discontinuities, in accordance with Clause 5.3.5 of CSA W59-03.

Assembly and fit-up tolerances for all weld joint types shall conform to CSA W59 Clause 5.4, or AWS D1.3, as applicable.

9.0 TACK WELDS & TEMPORARY ATTACHMENT WELDS

Tack welds that are incorporated into the final weld will be subject to the same quality requirements as the final weld; otherwise they shall be removed.

Temporary welds will be in accordance with approved welding procedures. When required to be removed, either by Clause 12.5.5 or by design, the surface is to be ground flush with the parent metal.

10.0 EXTENSION BARS, RUN-OFF PLATES & BACKINGS

Extension bars, run-off plates & backings used for welding of steels with a minimum specified tensile strength of up to 70 ksi (480 MPa), may be any of the steels listed in Tables 11.1 or 12.1 of CSA W59.

Extension bars, run-off plates & backings used for welding of steels with a minimum specified tensile strength exceeding 70 ksi (480 MPa), will be of the same material as the base material to be welded.

Spacers will be the same material as the base material to be welded.

Backing for groove welds will be continuous for the full length of the joint. Where backing is composed of individual lengths of bars, they will be carefully aligned and welded with a complete penetration groove weld into one continuous member.

Backing used to make circumferential welds in splices of statically loaded hollow structural members and pipe need not be continuous.

11.0 PREHEAT

Preheating of carbon steels is not normally required in temperate conditions for materials less than 1½" in thickness.

Welding or tacking shall not be performed when the ambient temperature is lower than 0° F (-18 C) without express consent of the Engineer. When the base metal temperature is below 32° F (0 C) OR the minimum temperature outlined in Table I, Appendix B for the welding process, filler metal classification, material specification or thickness being used, it shall be preheated.

The minimum preheat temperature to be obtained before welding or tacking shall be in accordance with Table 5.3 CSA W59-03, which is reproduced in Appendix B. Welding shall be done at a rate which ensures that the minimum preheat is maintained or exceeded.

The minimum preheat temperature shall be applied for a minimum distance equal to the material thickness, but not less than 3", both laterally and in advance of the welding.

If welding/tacking is interrupted for some time so that the temperature of the base metals falls below the minimum preheat temperature, arrangements shall be made to preheat again prior to recommencing welding/tacking.

The weldment shall be allowed to cool naturally to the ambient temperature without any external quench media being supplied. Any cold air, drafts, or moisture, shall be avoided during the cooling time until the weldment cools down to 600 °F (315 C) maximum.

12.0 ELECTRICAL CHARACTERISTICS

Welding current shall be DC reverse polarity with amperage and voltage settings as noted in the individual welding procedure data sheets attached. Welding machines shall have a variable voltage characteristic and deliver at least 32 arc volts.

Arc voltage is proportional to arc length. The longer the arc is away from the work piece, the wider the weld bead will be and the shallower the penetration. The average recommended voltage is shown in each welding data sheet. Arc voltage is correctly defined as the voltage between the wire tip and the work piece and is 2-3 volts

lower than the voltage measured between the terminals on the power source.

12.0 ELECTRICAL CHARACTERISTICS (Cont'd)

Stick out dimension used is shown in each welding data sheets. The contact tube must be tight and clean and must be changed from time to time.

13.0 WELDING TECHNIQUE

The welder, the work, and the welding consumables shall be adequately protected against the direct effect of wind, rain, and snow, and all reasonable means shall be provided to enable the welder to work in reasonable comfort.

When welding is required to be performed in a windy environment, the work area shall be protected by a suitable shelter which is constructed of material which will reduce the wind speed to not more than 5 mph (8 km/h).

Refer to the WPDS for the precise GMAW variables to be used in a particular thickness and joint configuration, position and parameters, such as stick-out, gas flow rate, travel speed, passes & layers, etc.

Welding currents must be within the specified limitations of the respective manufacturer and in addition should not vary more than ± 10 amps maximum from the currents noted on the individual Data Sheets. Arc voltage shall not vary more than ± 1 maximum from that noted on the individual welding data sheets.

The filler wire should point at the bottom plate close to the corner of the joint for the fillet welds 5/16" and larger in horizontal position. The angle between the filler wire and the bottom plate should be less than 45 degrees because with this position the molted metal is caused to wash up on to the vertical member.

If root porosity occurs, it may be decreased by pointing the filler wire directly into the joint and using an angle of 45 to 55 but this may cause weld spatters as well as a convex weld bead.

For 1/4" and smaller fillet welds, the filler wire should be pointed directly into the joint and at an angle about 40 degrees to the joint above horizontal.

For welding butt joints the gun should be positioned at an angle of from 5 to 15 degrees from the vertical and pointing toward the weld pool.

13.0 WELDING TECHNIQUE (Cont'd)

Stringer technique is commonly used to assure the proper shielding and entrapping of the flux.

The maximum weld deposit which can be made with a single pass shall be as shown in the following table:

Type of Joint	Pass Number	Welding Position			
		Flat	Horiz.	OH	Vert.
Fillet	Root Pass	3/8" (10mm)	5/16" (8mm)	5/16" (8mm)	1/2" (12mm)
	Filling Layers	1/8" (3mm)	3/16" (4mm)	3/16" (4mm)	1/16" (4mm)
Groove	Root Pass	1/4" (6mm)			
	Filling Layers	1/8" (3mm)	3/16" (4mm)	3/16" (4mm)	1/16" (4mm)

14.0 WELD METAL CLEANING

Any slag or flux remaining in the weld area after any weld pass shall be removed before applying the next covering pass.

All finished welds shall have the slag removed.

15.0 TREATMENT OF UNDERSIDE OF WELDING GROOVE

Prior to depositing weld metal on the underside of a welding groove, the root shall be gouged, ground or chipped to sound metal, unless otherwise specified on the applicable welding procedure data sheet.

Alternatively, the joint will include a continuous steel backing strip which will be included in the welded joint.

Back-gouging shall produce a groove contour substantially conforming to a pre-qualified single U-joint, with a depth adequate to ensure complete penetration into the previously deposited weld metal.

16.0 QUALITY

In general, the weld quality shall be such as to meet the requirements of Clauses 5.9, 11.5.4 and/or 12.5.4 of CSA Standard W59-03.

Welds shall meet the desirable or acceptable weld profiles shown in Appendix C.

Cracks or blow holes that appear on the surface of any pass shall be removed before depositing the next covering pass.

The procedure and technique shall be such that undercutting of base metal or adjacent passes shall be kept to a minimum. Undercut shall be limited to 1/32 inch (0.8mm) deep.

All welds shall be free from overlap.

Fillet welds in any single continuous weld shall be permitted to under-run the nominal fillet weld size required by 1/16" without correction, provided that the undersize weld does not exceed 10% of the length of the weld and does not occur at the ends of the web-to-flange welds in girders for a length equal to twice the width of the flange.

The reinforcement in groove welds shall not exceed 1/8 inch (3mm) and shall have a gradual transition to the plane of the base metal surface.

Surfaces of butt joints required to be flush shall be finished so as not to reduce the thickness of the thinner base metal or weld metal by more than 1/32" nor 5% of the thickness, whichever is smaller, or leave reinforcement that exceeds 1/32". All reinforcement must be removed where the weld forms part of a faying or contact surface.

17.0 CORRECTIONS

Corrections to defective welds or distortion must conform to all requirements of CSA W59, Clause 5.10.

18.0 HEAT TREATMENT AND STRESS RELIEVING

Post-weld heat treatment and stress relieving will not apply to structures welded under this specification unless specifically shown on the approved welding procedure data sheets. When required, procedures for heat treatment will be prepared and submitted for approval prior to start of work.

19.0 DATA SHEETS

The WPDS attached in Appendix D form part of this specification.

A change in any of the essential variables specified by CSA 47.1-09, which are shown in the attached WPDS will require a new data sheet.

Appendix A CARE OF FILLER WIRE

Filler wire must be clean, smooth, free of moisture, dirt or grease to function properly. Care must therefore be taken to store any filler metals in a clean, dry storage area which is adequately ventilated to avoid high humidity. Grease or other lubricants must be avoided including handling of the bare wire by hand.

Filler wire must be stored on spools which prevent kinks, slivers, sharp bends, scratches, inclusions and which are free to unwind without restriction. Wire spools should remain covered with clear cloth or plastic sheet until required and recovered from the shop when not in use.

Appendix B PREHEAT

Preheat of the base material in the immediate area of the joint is essential in medium and high carbon steels as well as in heavy sections. Preheat must also be employed when the ambient temperature dictates.

Preheat is used to:

- a) Reduce shrinkage stresses especially in highly restrained joints;
- b) Provide a slower cooling rate through the critical temperature (1600°F to 1330°F) or (870C to 720C), thus preventing excessive hardening and lower ductility in the heat affected zone;
- c) Provide a slower cooling rate through the 400°F (205C) range to allow for hydrogen diffusion.

Preheat and interpass temperatures for various steels covered by this specification must be applied with a minimum as shown in Table I.

Welding shall not be done when the ambient temperature is lower than 0°F (-18 C), except with express consent of the Engineer.

When the base metal is below the temperature listed for the welding process being used and for the thickness of the material being welded, it shall be preheated (except as otherwise provided) in such a manner that the surfaces of the parts on which weld metal is being deposited are at or above the specified minimum temperature for a distance equal to the thickness of the part being welded - but not less than 3 inches - both laterally and in advance of the welding.

Preheat and interpass temperatures must be sufficient to prevent crack formation. For quenched and tempered steel, the maximum preheat and interpass temperature shall not exceed 400°F (200C) for thickness up to 1 1/2 inches inclusive, and 450°F (225C) for greater thickness. Heat input, when welding quenched and tempered steel, shall not exceed the steel producer's recommendations.

Preheat and interpass temperature may be reduced when approved by the Engineer and/or the Bureau for techniques established by the Contractor that will guarantee satisfactory properties for the joint in its full length.

Table I Minimum preheat and interpass temperature (Ref. Table 5-3 of W59-03)

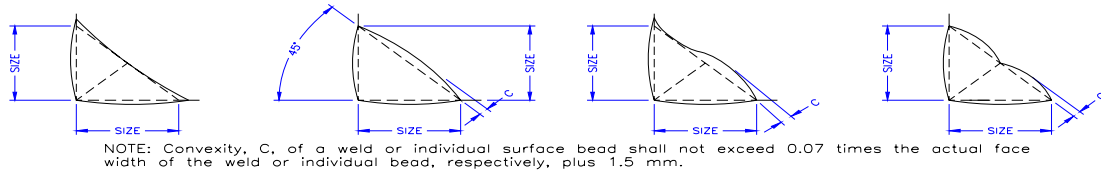
Thickness of Thickest part at point of welding (inches)	Welding Process			
		GMAW		GMAW Mild or alloy steel filler metals
1	2	3	4	5
		CSA G40.21 38W, 38WT 44W, 44WT 50W, 50WT 50A, 50AT 60A, 60AT 60W, 60WT	CSA G40.21 60 W, 60WT 70 W, 70WT 70A, 70AT	CSA G40.21 100Q 100QT
		ASTM A36 A53 Gr. B A106 Gr. B A242# A441 A500 Gr. A,B,C A501 A515 up to Gr. 60 A501 All grades A529 A570 All grades A572 Gr. 42, 50 A588 A606 A607 All grades A618 A633 Gr. A,C,D A710 Gr. A Cl 2 <2" A913 Gr. 50 A992/A992M	ASTM A515 Gr. 60,65 A572 Gr. 60, 65 A633 Gr. E A710 Gr. A Cl 2 <2" A710 Gr. A Cl 3 >2" A913 Gr. 60, 65	ASTM A514 A517
Up to 3/4 inclusive Over 3/4 to 1 1/2 Over 1 1/2 to 2 1/2 Over 2 1/2		None! 50 °F (10 C) 150 °F (65 C) 225 °F (107 C)	50 °F (10 C) 150 °F (65 C) 225 °F (107 C) 300 °F (150 C)	50 °F (10 C) 125 °F (50 C) 175 °F (80 C) 225 °F (107 C)

Grades suitable for welding.

! When the base metal temperature is below 32 °F (0 C), the base metal shall be preheated to at least 50 °F and this temperature maintained during welding.

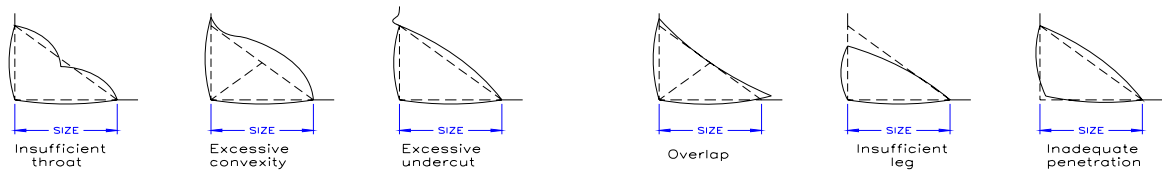
* Only for thicknesses up to 5/16" (8 mm).

APPENDIX C ACCEPTABLE AND DEFECTIVE PROFILES OF WELDS

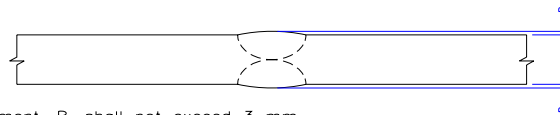


(a) Desirable Fillet Weld Profiles

(b) Acceptable Fillet Weld Profiles

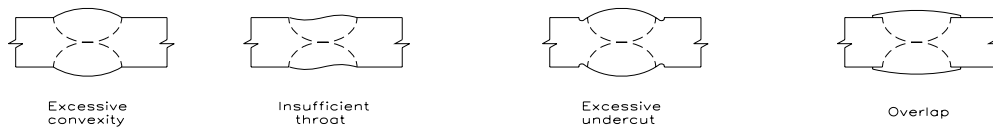


(c) Unacceptable Fillet Weld Profiles



NOTE: Reinforcement, R, shall not exceed 3 mm.

(d) acceptable Groove Weld Profiles in Butt Joints



(e) Unacceptable Groove Weld Profiles in Butt Joints

Notes:

(1) The faces of fillet welds may be slightly convex, flat, or slightly concave. Except at outside corner joints, the convexity shall not exceed $0.07 \times \text{width of face or bead} + 1/16''$ (1.5 mm).

(2) The finishing passes of all groove welds in butt joints shall provide a reinforcement at the centre of weld not exceeding $1/8''$ (3mm). The reinforcement shall be built up uniformly from the surface of the parent metal to a maximum at the centre of the weld. There shall be no valley or groove along the edge or in the centre of the weld. The deposited metal shall be smooth and uniform in cross-section.

Appendix D Welding Procedure Data Sheets